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格鲁吉亚的可持续发展及绿色能源计划项目研究

Sustainable Development and Energy Efficiency Programs in Georgia

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摘 要

在本文中，我们探讨格鲁吉亚公司对采用节能照明技术的偏好及研究他们参与由国际组织 EBRD, SEFF 提供的绿色信贷的决定因素。通过联合分析邮寄问卷，我们调查了第比利斯（格鲁吉亚首都）在电力照明方面使用较多的机构。参与机构除了提供机构基本信息外，还对不同的基础方案进行排序。基础方案由多个属性组成，例如二氧化碳的排放量，电力成本和绿色信贷要素。通过联合分析法，我们发现，格鲁吉亚公司愿意为了变得更可持续发展和提高成本效益去投资 LED 照明节能技术。此外，我们发现，商业性贷款比 EBRD 绿色贷款更具吸引力。其中主要原因是 EBRD 目前所提供的现金返并不是一个具吸引力的选择。我们发现，在利率和时间成本的降低能够更有效地吸引企业申请 EBRD 绿色贷款，以提升节能照明技术。

关键词：LED 技术；可持续发展；联合分析

Abstract

In this paper we examine Georgian companies’ preferences for adopting LED lighting technologies and investigate the determinants of Energy Efficiency financing program Developed by EBRD, SEFF. Conjoint questionnaire together with research flyer was mailed to major organizations of Tbilisi (the capital of Georgia), which are heavy users of electricity in terms of lighting. Participant organizations were asked to answer survey questions as well as rank appropriate choice based programs, which varied according to the several attributes, such as CO_2 emissions, electricity costs and financial program attributes. Conjoint analysis was carried out to analyze two major research questions. We find that Georgian companies are willing to invest more in LED lighting technologies In addition, we find that the SEFF loan is less attractive than commercial loans. More specifically, cash back currently offered by SEFF is not an attractive option. We find that the reduction in interest rate and time cost can be more effective to attract companies to apply for the SEFF loan to upgrade their lighting technologies.

Key words: LED Technologies; Sustainable Development; Conjoint Analysis

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Introduction

"The decisions of architects and urban planners made today will define the world we have in two or three generations' time. Also, the energy policy decisions of today will shape the world for our children and children's children. Both European energy policy and local initiatives make a difference in how we tackle these challenges. How we build the cities of the future."

(EU Commission 2014)

Energy is an indispensable element for economy and social development. Yet, conventional forms of energy production, distribution, and consumption are linked to environmental degradation, which threaten human health and quality of life and the delicate balance of the earth's ecosystems (Dainora Grundey, 2008). Globalization has brought not only a wide variety to our choices, but an increased level of environmental pollution and challenges as well. Developing countries are pushed to exploit their resources, as advanced technologies are less affordable there, and raise the question of world sustainability to the forefront. More specifically, developing countries are using their resources less effectively than developed countries with wealthier economies, access to high technologies, and a more skillful and educated workforce.

In terms of world-wide lighting based Energy consumption, there are approximately 12 billion bulbs in use on the earth (McKinsey Lighting the Way.2012). The average bulb type consumes between 6-100 Watts of electricity each, which results in CO_2 emission and contributes to the rise in Greenhouse gas levels thereby threatening the world's sustainability .

Most developed countries have already adopted regulations and programs in order to limit energy usage specifically in the lighting sector to improve sustainability, while emerging and developing countries still struggle to develop proper policies as energy efficient bulb prices are relatively high compared to incandescent and other less efficient options. For instance, Brazil and Venezuela started a phase out program in 2005 (Derbyshire, 2009) while European Union and Australia began their phase out in 2009 (EE Lighting, 2014). Most phase out regulatory schemes ban the import and/or sale of incandescent light bulbs, as they have been deemed not sufficiently energy efficient. Some other countries, like Argentina, Russia and China,   are utilizing a scheduled phase out scheme starting in 2012.. Canada, Mexico, Malaysia and South Korea are slated to begin their schemes in f2014 (Patti Okeefe, 2014).

Opportunities for acquiring rebates or incentives are possible from both governmental and nongovernmental organizations. A growth in intermediary companies can be seen in the US and Canada which promote Energy Efficiency (EE) in utility and state rebate programs administered by the government. For example, BriteSwitch is helping companies to analyze the profitability of all LED replacement projects and helps to acquire state rebates. NY Serda offers On-bill recovery loans, which analyses the investment made on lighting upgrades, against a specific utility bill and calculates monthly payments based on expected energy cost. Puget Sound Energy offers instant rebates and business lighting incentive programs. Other governmental and nongovernmental organizations operating in Europe also promote energy efficiency. For instance, European Investment Bank offers a credit line for energy improvements, Green Deal Provides energy efficiency improvements and financial solutions to interested households.

Although there are some EE financing programs available for developing countries a concern over deficiency of information dissemination regarding new Energy Efficient technologies in the lighting sector results in a lack of program support and awareness. Hence, in this paper we examine Georgian companies' preferences for adopting energy efficient technologies in the lighting sector. Furthermore, we investigate the determinants of energy efficient financing program offered by European Bank of Reconstruction and Development (EBRD) and participation of those companies to upgrade their lighting technologies.

In order to gather proper information a questionnaire together with a research flyer was mailed to major organizations located in Tbilisi, Georgia. The organizations selected were those which consumed a large amount of electricity for lighting (see Appendix, Table 1). Participant organizations were asked to answer survey questions, as well as, rank appropriate choice based programs, varied according to several attributes, such as CO2 emissions, electricity costs, bulb specifications, and financial program attributes. Conjoint analysis was carried out to analyze two major research questions and also develop simulation policies. The simulation policies were designed to be adjusted according to individual characteristics, attribute choice, and evaluate programs positive and negative effects which face different policymakers.

As a result, we find that Georgian companies are willing to invest more in energy efficient lighting technologies in order to become more sustainable and cost effective. Organizations prefer to borrow financial support for replacement projects rather than self-finance, but on the other hand, energy efficient financing programs were found to be less attractive than commercial loans.

In the next section of the study, we review LED technologies and existing financial programs for energy efficiency. In the second section, we discuss Methodology and Design of research followed by Results and Finding section. We finalize paper with Conclusion. You can review our survey questionnaire in appendix**.**

Literature Review

The Geography of the Research and Statistical Data

Georgia is a country with 4.49 (million) population, located in the eastern region of Europe, with an area of 69,700km^2 and a real GDP growth rate of 6.2% (Statistics Department of Georgia, 2012).Furthermore according to the Ease of Doing Business Index Georgia ranks on the 8th place and on the 21st by the Index of Economic Freedom among 183 countries(World Bank, 2009-2013). Georgia produces yearly 1.12 (Mtoe) of energy, with an electricity consumption count of 8.6 (TWh) and a CO2 emission count of 6.26(Mt), which is 1.92 (MWh) per capita electricity consumption with 1.4 tons of per capita CO2 emission (International Energy Agency, 2013).

Currently, many papers address the relationship between economic growth and environmental quality. As Nemat Shafik (1994) says in his paper, at one point economic activity inevitably leads to environmental degradation, while at the other extreme, is the view that those environmental problems worth solving will be addressed more or less automatically as a consequence of economic growth (Shafik ,1994). Therefore, the role played by developing countries in joining the commitment to reduce CO2 emission and shape sustainable policies is very important and should not be overlooked (M.Galeotti, A.Lanza). One of the most important issues raised in both The Earth Summit held in Rio de Janeiro in 1992 and the 1997 Kyoto Summit, was related to the role that developing countries could play in their sustainability commitment through designing appropriate policies (M.Galeotti, A.Lanza).

Georgia is a country with a developing economy. According to the World Bank's Energy Sustainability Index, Georgia is ranked 65th out of 142 countries (World Energy, 2013). The reason why Georgia has the lower CO2 is not in advanced technologies and fine governmental policies that country is following but mostly because it is listed as one of the least industrialized countries as well (see Table 1).

Table 1

CO2 Emission and Industrialization

Country Name	CO2 emissions (metric tons per capita) Average 2007-2010	Industry, value added (% of GDP) Average 2007-2010
Georgia	1.40	22.6
East Asia & Pacific (developing only)	4.46	45.9
Europe & Central Asia (developing only)	5.31	30.9
Latin America & Caribbean (developing only)	2.67	32.8
Middle East & North Africa (developing only)	3.87	42.9
Sub-Saharan Africa (developing only)	0.85	31.9

Source :World Bank Data, 2007-2010

Currently, the Georgian government is developing the "100 Factory Plan" The subsection of this plan, "Preferential Agrocredit Project" has already been put into action (Ministry of Agriculture, 2014). According to this project privileged governmental loans would be provided to individuals and businesses to improve agricultural industry in Georgia. If this ambitious "100 Factory Plan" will take full affect, planners will be required to consider environmental issues and carry out sustainable projects to avoid environmental degradation.

SEFF program by EBRD Bank, financing energy efficiency projects in Georgia

In October 2013 Georgia signed a fastened EU association agreement, which marked the first step towards ratification in European Union (D.Keating, 2013). European Union assistance to Georgia mainly takes the form of Annual Action Programs under the European Neighborhood and Partnership Instrument (ENPI). Other funding sources are thematic assistance programs, which focus on specific sectors, such as, human rights or civil society concerns, among others (EUROPEAID, 2013). One of these programs, Sustainable Energy Financing Facilities (SEFF), was launched by European Bank of Reconstruction and Development (EBRD) bank to support energy efficiency projects in developing European countries.

Through SEFF, the EBRD extends credit lines to local financial institutions that seek to develop sustainable energy financing as a permanent field of business. Finance for sustainable energy projects is provided for two key areas: energy efficiency and small-scale renewable energy. Local financial institutions on-lend the funds to their clients which include small and medium-sized businesses, and corporate and residential borrowers (EBRD, 2013). Currently SEFF has more than 20 programs running in developing countries in Europe.

Energocredit is a credit line that was designed by EBRD to increase the competiveness of Georgian business. It can be obtained through 2-3 local banks, which provided launching seminars on the EE loans. Approximate 200 corporate clients attending the Energy Credit line presentation which was held in 2010 (T. Abshilava, L.Chkadua, 2013).Compared to business loans provided through commercial banks, Energocredit loan offers cash back on investment. Cash Back is a refund payment up to 10-15% of initial investment, to motivate consumers. Thus after borrowing through Energocredit project creditors will be able to cover nearly one month interest payment.

As a result of old, inefficient machinery, technologies, and buildings, many companies in Georgia use up to three times as much energy per unit of GDP as their western competitors. For energy intensive companies, this is a serious disadvantage, and will likely become more intensive if energy prices increase (Energocredit, 2012). In light of this concern, the EBRD put in place a EUR 35 million Energocredit credit line to provide loans through local partner banks for up to USD 2.5 million to be granted to companies in Georgia with large energy saving potential. For such companies, the savings potential is so large, they can often repay big investments in very little time, with the additional benefits of also boosting capacity, profits, and competitiveness. To illustrate, one Energocredit customer repaid a USD 3.3 million investment from energy savings in just 1.3 years, as it was previously using twice the energy per ton of production in comparison with international firms (Energocredit,, 2012).

To date, Energocredit has developed 35 industrial projects. While the number of approved loans has been fewer than anticipated from 2008, the average loan size was significantly large. The following is the approved loan distribution: 51% invested in Renewable Energy Projects, 37% in industry, and the remaining 12% was credited to commercial buildings (Energocredit, 2012).

In conclusion, the number of completed projects is relatively few despite large loan amounts. In interviews with lighting field experts, the time costs in combination with other varying complications were listed as reasons to avoid the credit lines offerings as a means to implement lighting based energy EE replacement projects, which is one of our research focuses.

LED Lighting Technologies

The Energy Star Program founded by the U.S. Environmental Protection Agency (EPA), is a voluntary program that helps businesses and individuals save money and protect the environment through superior energy efficiency. According to the organization, LEDs, or light–emitting diodes, are semiconductor devices that produce visible light when an electrical current passes through them. LEDs are a type of Solid State Lighting (SSL), as are organic light–emitting diodes (OLEDs), and light–emitting polymers (LEPs). LED lighting differs from incandescent and compact fluorescent lighting in several ways, but their main benefits are efficiency, durability, versatility, and longer lifetime (Energy Star, 2013).

LED lighting has already been adopted in most developed countries. Despite the higher prices points of LEDs, their heightened performance, when compared to existing lighting products, has motivated countries to develop rebates and special financing programs. Those programs are designed to facilitate product adoption and support local, regional, and world sustainability. The McKinsey report forecasts LED based lighting technologies should completely replace other lighting forms worldwide by 2016, as it has been named the best sustainable substitute product to incandescent traditional lighting (McKinsey, 2012).

In the Georgian market, LED bulbs are available however, as discussed above the price of LED bulbs are relatively high compared to traditional solutions. Furthermore, the lack of financial solutions and informational availability makes this product even less affordable to Georgians. In our research, energy efficiency programs are analyzed to consider LED bulbs in the lighting sector, due to its sustainability and benefits to environment (see Table 2).

Table 2

Light Bulb Comparison by Price and CO2 Emission

	Price in GEL	CO2 Emission in KG
Incandescent Bulb	0.8	1998
Fluorescent Bulb	4	466
LED Bulb	9	233

Source: Bright.ge, Design Recyclenic

Research Design and Methodology

Research design was carried out after successful interviews with lighting field experts which were conducted in Tbilisi, Georgia (Georgia, 2013). On the second stage, E-questionnaires together with research flyers were mailed to middle and high level managers in different organizations in industrial, commercial, and public service sectors, as their share of electricity usage in lighting is higher for those companies (see Appendix, Table1). Each respondent was asked to fill out the questionnaire and then rank the programs included in the conclusion part of each section. 50 surveys out of 60 were successfully completed.

Two main research programs were developed in this study to address the major research questions. The first program analyzes companies’ preferences to contribute to environmental sustainability. The survey design consisted of three parts: company demographics, LED knowledge, where respondents were asked some basic LED product questions, and energy efficiency programs. Together with number of questions orthogonal design choice based program was offered for ranking. We wanted to understand the willingness of Georgian companies to pay more in order to become more energy efficient and cost effective. The main attributes for the sustainable trade-off program were: CO_2 emission per bulb, bulb price and annual electricity cost. Accordingly, 6 orthogonally designed cards were developed for ranking (see Table 3). After data collection and careful analyzes, policy simulation was carried out. Three types of different light bulbs were incorporated and assigned their real values. Incandescent light bulbs, compact fluorescent light bulbs and LED light bulbs were chosen, as representatives of the three different technologies currently available in lighting industry (According to cost effectiveness and energy efficiency).

Designing the second program was much more complex. In the second program we analyzed energy efficiency program adoption. The last section from the survey was completely designed for energy efficiency programs. The major attributes for EE financing programs were: a self-financing option, time cost associated with financing mode, loan-cash back, loan-Interest rate, bulb price- which included high quality and normal quality LED bulb, bulb lifetime –which is one of the major specifications to define the light bulb quality. Besides delivering 8 orthogonally designed cards, 2 more cards were added for self-financing option (see Table 4).

In both cases we assumed that companies would be offered to replace traditional lighting into LED lighting technologies, which is listed as a green technology by EE companies (Energocredit, 2013).

Table 3

Program 1. Sustainability Trade Off-Conjoint Choice Cards

Card N		Rank 1-6
1	CO_2 Emission 233KG / Bulb Price 0.8 GEL / Electricity cost 14.52 GEL	
2	CO_2 Emission 233KG/ Bulb Price 9 GEL/ Electricity cost 14.52 GEL	
3	CO_2 Emission 233KG/ Bulb Price 9 GEL/ Electricity cost 1.9 GEL	
4	CO_2 Emission 1998KG/ Bulb Price 0.8 GEL/ Electricity cost 1.9 GEL	
5	CO_2 Emission 1998KG/ Bulb Price 0.8 GEL/ Electricity cost 14.52 GEL	
6	CO_2 Emission 1998KG/ Bulb Price 9 GEL/ Electricity cost 14.52 GEL	

Table 4

Program 2. EE Financing Program Adoption Conjoint Choice Cards

Card N		Rank 1-10
1	Time Cost 5 Days/ Cash Back 0%/ Interest Rate 12%/ Bulb Price 9 GEL/Lifetime 10’000 hrs.	
2	Time Cost 5 Days/ Cash Back 0%/ Interest Rate 14%/ Bulb Price 18 GEL/Lifetime 25’000 hrs.	
3	Time Cost 5 Days/ Cash Back 15%/ Interest Rate 12%/ Bulb Price 9 GEL/Lifetime 10’000 hrs.	
4	Time Cost 5 Days/ Cash Back 15%/ Interest Rate 14%/ Bulb Price 18 GEL/Lifetime 10’000 hrs.	
5	Time Cost 30 Days/ Cash Back 0%/ Interest Rate 12%/ Bulb Price 9 GEL/Lifetime 10’000 hrs.	
6	Time Cost 30 Days/ Cash Back 0%/ Interest Rate 14%/ Bulb Price 18 GEL/Lifetime 25’000 hrs.	
7	Time Cost 30 Days/ Cash Back 15%/ Interest Rate 12%/ Bulb Price 18 GEL/Lifetime 25’000 hrs.	
8	Time Cost 30 Days/ Cash Back 15%/ Interest Rate 14%/ Bulb Price 9 GEL/Lifetime 25’000 hrs.	
9	Self-Financing/ Bulb Price 9 GEL/Life time 10’000 hrs.	
10	Self-Financing / Bulb Price 18 GEL/Life time 25’000 hrs.	

Orthogonal Design

Orthogonal Design was first introduced and described in Design of Experiments by Sir Ronald Fisher (1935) and applied to some agricultural experiments in England. Over the years it has been utilized in different types of research including agricultural, business and marketing, science, and operations research (Zurovac, Jelena, and Randy Brown, 2012).

Orthogonal Design is an experimental design used to test the comparative effectiveness of attributes and its levels each of which can take two or more variants. In our case, research-specific attributes and its levels are defined. An algorithm is then used to generate specific set of random combinations that constitute Orthogonal Design for the number of attributes and levels (see Table 3, Table 4).

In general, orthogonal arrays are used in statistical experiments that call for fractional factorial design. Both Pure and Asymmetric orthogonal arrays have been used in this research design. In Program 1 design “Pure” Orthogonal Array design was utilized, where all attributes have the same number of levels (Raghavarao 1971, Hedayat et al 1996). While Program 2 uses “mixed-level” or “asymmetric” Orthogonal Array design, which are found in Addelman and Kempthorne (1961), and later formally defined in Rao(1973). In Asymmetric orthogonal design, different attributes have different numbers of levels.

Orthogonal design enables one to express the problem of finding the minimal number of runs in orthogonal array of given strength as a linear programming problem (Sloane, Stufken, 1996)

Rank-Ordered Logit (Rologit)

In our research, Rologit regression model is used to understand consumer preferences and the decision making process. Rologit represents choice-based method of conjoint analysis (Hair et al. 2010) and is one of the best options to analyze influential attributes affecting the decision making. It fits the rank-ordered logistic regression model by maximum likelihood (Beggs, Cardell, and Hausman 1981). This model is sometimes known as the Plackett-Luce model (Marden 1995), and as exploded logit model (Punj and Staelin 1978). Furthermore, Rologit is